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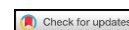
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Determinants of Female Students' Choice of STEM Programmes in Tertiary Education: Evidence from Senior High Schools in Ghana

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ABSTRACT

This study examined the determinants of Senior High School (SHS) female students' choice of STEM programmes in tertiary education in Ghana. Specifically, the study aimed at exploring: (a) school-related factors, (b) home-related factors, and (c) person-related factors which influence female SHS students' choice of STEM programmes in tertiary education in Ghana. The study was grounded in the positivist's paradigm. A cross-sectional survey design was used as the research design. The study was targeted to final-year female students in SHSs in three regions in Ghana. Single-sex male SHSs were excluded because only female students participated in the study. Through a multi-stage sampling procedure, questionnaires were administered to 1,938 final-year female students in 15 SHSs. Prior to the data collection, the questionnaire was validated using Response Factor Analysis (RFA) and Kuder-Richardson reliability estimate. Binary logistic regression with 1,000 bootstrap samples was used to analyse the data. The study revealed that school-related factors, such as the course of study, elective mathematics status, and interest in mathematics and science, influenced female students' choice of STEM programmes in tertiary education. Home factors (e.g., education level of parents, socioeconomic status) and personal factors (e.g., self-confidence, career indecision, having a role model in STEM, locus of control) were also found to play a significant role in female students' choice of STEM programmes in their tertiary education. Conclusions and recommendations were made based on the findings of the study.

Keywords: STEM, Female students, Senior high schools, Tertiary education, Gender, Home factors, School factors, Personal factors.

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Highlights of this paper

- This study explored the factors influencing SHS female students' intentions to choose STEM-related programmes in their further education.
- Final year female students in public SHSs in Ghana were sampled and information was obtained from them using validated questionnaire.
- The study revealed that factors from the school, home and personal played a significant role in female students' choice of STEM programmes in their tertiary education.
- Recommendations were made to relevant stakeholders for actions to be taken.

1. INTRODUCTION

Sustainable Development Goal (SDG) 5 focuses on achieving gender equality, and women and girls empowerment. The targets for the SDG 5 entail the eradication of discrimination of all forms, gender-grounded violence and marriage at an early age, heightening women participation in decision-making at all levels, and increasing universal access to reproductive and sexual health services (United Nations Educational Scientific and Cultural Organisation [UNESCO], 2017). The African Union (AU) has also joined in the campaign for gender equality in diverse fields of endeavour. In its Agenda 2063, the AU has advocated for more girls enrolling in Science, Technology, Engineering and Mathematics (STEM) subjects in Africa for rapid economic development in order to bridge the gender gap in STEM (African Union [AU], 2015).

The level of illiteracy in Ghana is increasing despite the nation's historical milestone of free education at some levels of education from the year 1957 up-to-date. For females, in particular, enrolment in basic, senior high and tertiary education appears to be lower than for males. Supporting this claim, Shabaya and Konadu-Agyemang (2004) indicated that gender gap in education favour males. This gender gap at the basic, senior high and tertiary levels of education is 8.4 percent, 22.2 percent and 55.6 percent respectively. Nguyen and Wodon (2013) also reiterated that there exists gender inequality in participation in education among the age group of 21 to 24 years. The authors further indicated that 84.1 percent of girls as compared to 90.7 percent of boys enroll in primary school with a completion rate of 86.5 percent for girls and 92.7 percent for boys. A similar trend was found in the completion of Junior High School with 65.1 percent for boys and 51.2 percent for girls. It worthwhile to say that in-between enrolling and completing education, accessibility is a negotiated gendered process which is endorsed on a day-to-day basis (Dunne *et al.*, 2007) among parents, families, schools and the society at large (Humphreys *et al.*, 2015), increasing identities of dropouts in schools in Ghana.

Data from the World Bank (2019) on gender parity index from 2011-2018 for Ghana shows that access to education still favours boys and men. As shown in Figure 1, the gender parity index for the 9-year period was all below 1. Gender parity index below 1 show that access to education favours males. On the other side, access to education favours female if the gender parity index is above 1. Although the index has improved over the years due to some intervention programmes introduced by stakeholders, it is still not up to 1- equal access to education.

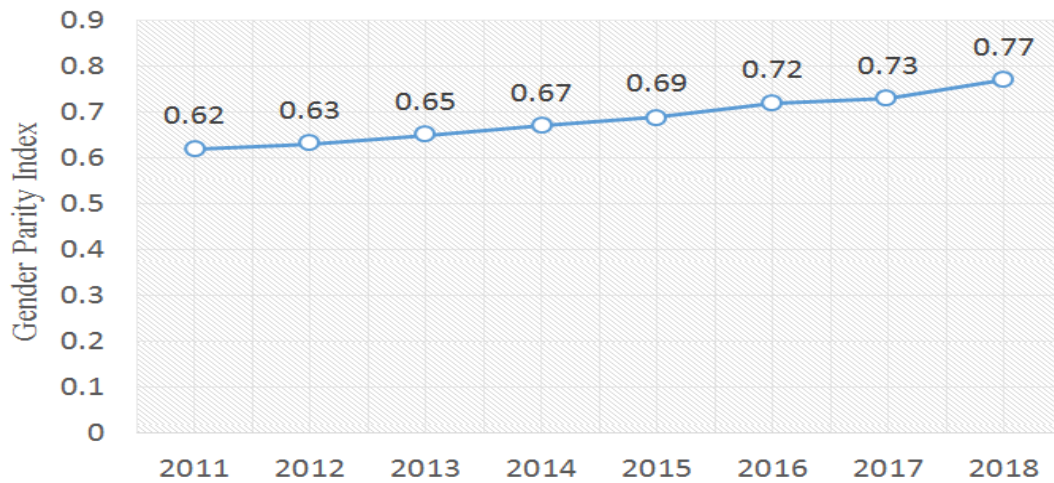


Figure-1. Gender Parity Index for Ghana from 2011-2018.

Source: World Bank (2019).

Achievement in and access to tertiary education among women in Ghana are inhibited (Daddieh, 2003). Attrition, subject choice and recruitment in tertiary education are gendered. Pupils who had preferences for programmes they were admitted to, made decisions often based on gender-traditional choices, with more females than males being motivated by their parents and peers in taking such decisions (Mastekaasa and Smeby, 2008). For instance, the traditional belief that boys are more competent in mathematics than girls usually results in more boys enrolling in mathematics-related subjects (Boateng and Gaulee, 2019). Report by the Global Education Monitoring Team (2018) has also noted that women in Ghana account for less than one-quarter of all Science, Technology, Engineering, and Mathematics (STEM) degrees. Although giving girls equal access to STEM education is a legal requirement: all should have equal access and opportunity to education (human right) (European Commission, 2012; Marginson *et al.*, 2013; Lee and Pollitzer, 2016) there is still challenges facing women in this respect (Ankoma-Sey *et al.*, 2019).

Not only do women have less probability of enrolling in STEM programmes but also have fewer odds of presenting themselves for programmes in STEM as a result of stereotype thinking (McClelland and Holland, 2015). Under-representativeness and low participation of women in STEM-related programmes in secondary and tertiary education are partially due to their slow amalgamation into STEM-related jobs (Xie and Shauman, 2003). It is not out of place to say that few women are in STEM-related areas because relatively few girls enroll in STEM-related programmes. For this agenda of more girls moving into STEM to materialise, then more girls must enroll in STEM-related programmes in higher education (Daddieh, 2003; Dunne *et al.*, 2007; UNESCO, 2017). In Ghana, such decision is critical at the Senior High School (SHS) level, where after completion students are opened to a wide range of programmes to choose from at the tertiary level (Boateng and Gaulee, 2019). Existing studies on gender and STEM have been extensively conducted using different population (female faculty and students already in STEM, all students including both sexes in STEM and those not in STEM-related programmes, and stakeholders in STEM) (Acheampong, 2014; Edzie, 2014; Bahar and Adiguzel, 2016; Awan *et al.*, 2017; Boateng, 2017; Boateng and Gaulee, 2019). From the viewpoint of UNESCO (2017) factors serving as obstacles to the participation of girls in STEM in Ghana include stereotype thinking, insufficient awareness creation on the essence of STEM, and gender and unfriendly insensitivity in classroom instruction. Other factors, as discussed by UNESCO, were insufficient funding by the gender units of Ghana Education Service (GES), unclear gender policy guidelines in the education sector, and restricted inter-sectoral partnership among the several government agencies and ministries in promoting the education of girls. Scholars like Erinoshio (1994) also attributed low participation of females in

STEM to biological, social and psychological factors. Citing the biological factors, [Erinosho \(1994\)](#) stated issues regarding the phenotypical composition of women in connection with their visual-spatial and analytical skills needed for intangible reasoning in mathematics and science. The social perspective was based on the critical roles of the school, home and society in indoctrinating girls with feminine ideologies ([Birke, 1986](#); [Erinosho, 1994](#); [Witt and Wood, 2010](#); [Ankoma-Sey et al., 2019](#)). These social activities, for some time, develop to manifest in psychological traits (personality) in the form of self-concept, interest and attitude ([Moss-Racusin et al., 2012](#)). Thus, girls are trained to develop concern, feelings, and emotions for nature more so than for mechanical associations with physical substances ([Erinosho, 1994](#)).

These biological, social, and psychological issues highlight the dismal statistics relating to female participation in STEM in Ghana, as has been earlier indicated. At several educational levels in STEM, women bump into unconscious and conscious teacher/faculty bias due to issues of gender ([Moss-Racusin et al., 2012](#)) as males are given greater chances in the education process because of their active engagement by faculty/teachers ([Hall and Sandler, 1982](#); [Johnson, 2007](#)). Of particular concern in the discussion on broadening STEM participation in the under-representation of racial minorities, women, and students of low socioeconomic status (SES) (e.g., ([Anderson and Kim, 2006](#); [Herrera and Hurtado, 2011](#); [Schultz et al., 2011](#))). This study, therefore, explored the influential drivers of SHS female students' choice of STEM programmes in further education.

1.1. Social Cognitive Career Theory

The Social Cognitive Theory (SCCT) was developed based on [Bandura \(1986\)](#) general social cognitive theory. [Lent and Brown \(2006\)](#) noted that the SCCT highlights the interrelationship among environmental, individual, and behavioural elements that are presumed to influence one's career and academic choice. Key issues raised in the framework of the theory were self-efficacy, interests, beliefs, environmental supports, outcome expectations and choice actions ([Lent et al., 2010](#)). In studying the choice of STEM programmes and its related issues, SCCT provides a suitable theoretical lens ([Lent et al., 2000](#)) and thus, the theory has been employed in some studies associated with the intentions to choose STEM-related fields (e.g., ([Betz and Hackett, 1983](#); [Hackett et al., 1992](#); [Lent et al., 2008](#); [Byars-Winston et al., 2010](#))).

SCCT postulates that the will-power to produce a specific choice can be described as a function of goals and interests. Meanwhile, interest in a choice action is related to learning experiences and self-reference confidence. Given the central significance of initial experience in mathematics in future STEM education (e.g., ([Bowman, 1998](#); [Adelman, 1999](#); [Marshall et al., 2011](#))) intentions to choose STEM-related programme can be said to be a function of motivation and learning mathematics and science-related subjects at the secondary level. According to [Pajares and Kranzler \(1995\)](#) intentions to choose STEM-related programmes is related to previous academic achievement and self-efficacy beliefs. Other studies also mentioned students' attitudes towards mathematics and science lessons as key drivers of students' choice of STEM programme ([Eccles, 1994](#); [Trusty, 2002](#)).

SCCT also stresses on the role of environmental barriers and supports in the determination of choice of action. In the higher education context, students' decision to pursue STEM programmes is a response to the situational supports and barriers—academic, financial, or social. Students transiting to tertiary education requires a number of demands including academic integration into college, the need for financial resources, and numerous external demands. The product of this process may exhibit either barriers or supports and consequently influence students' choice of programmes in tertiary education.

After digesting various findings from previous empirical studies together with the social cognitive career theory, we reorganised the influential factors driving SHS students' choice of STEM programme in tertiary

education into three dimensions. Factors which were related to the home were grouped and named as “home factors”. Issues surrounding the individual personalities were labelled as “personal factors”. Key drivers at school which influenced students’ decisions to enroll in a particular programme were referred to as “school factors”. These factors interact to influence students’ choice of the STEM programme. Figure 2 shows how the variables in this study are related.

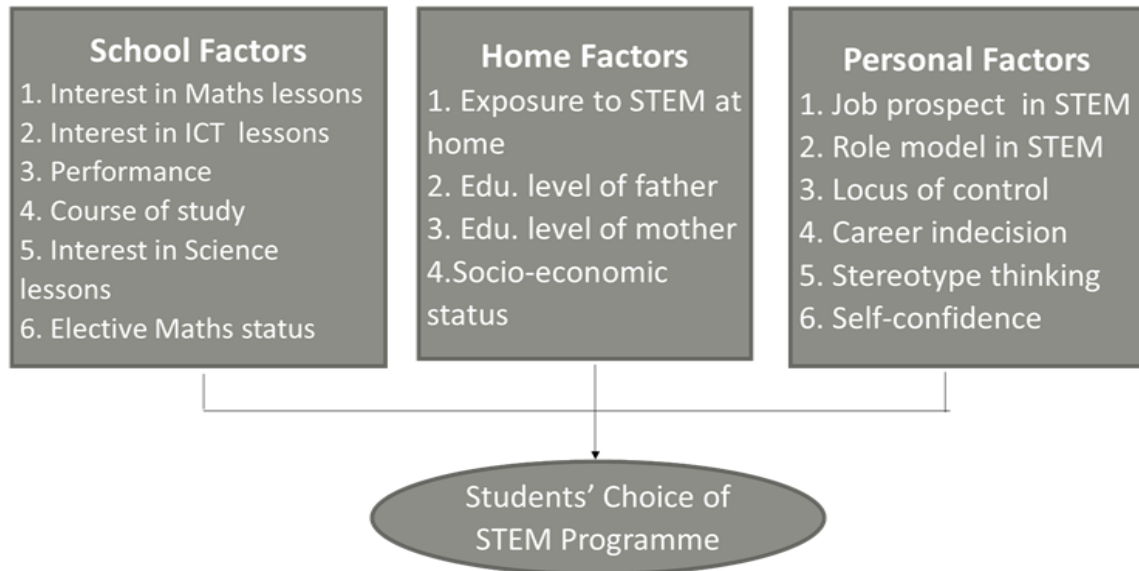


Figure-2. Conceptual framework showing the influence of school, home, and personal factors on SHS students’ choice of STEM programmes in tertiary education.

1.2. Context of the Study

Ghana’s education system is structured into Basic, Senior High and Tertiary Education. The basic education consists of Primary School and Junior High School which takes 6 and 3 years respectively to complete. After effectively passing the Basic Examination Certificate Examination (BECE) at the Basic School level, pupils are then placed in SHS. The SHS takes 3 years to complete. After the completion, students write a universal examination known as West African Senior School Certificate Examination (WASSCE). Students who successfully pass the WASSCE become eligible to apply for any tertiary institution in Ghana. Tertiary education comprises 3 to 6 years of study depending on the programme and the certificate awarded. For diploma certificates, the length of study is 3 years. For the bachelor’s degree, students study on the programme for four years. Other programmes, like Doctor of Optometry and Doctor of Medicine, take 6 years duration. This study employed female final year SHS students at the verge of completing school.

2. METHOD OF INQUIRY

The study was grounded in the positivist’s paradigm. The researchers believed that there is the existence of reality which is independent of them (investigators) such that this reality can be discovered in a stable and objective manner (Krauss, 2005). In relation to this study, female students’ choice of STEM programmes is steady and can be subjected to empirical testing. We used a “narrow lens” by distancing ourselves from the subject matter, the entity observed, and methods of this research (Pansiri, 2005). This resulted in the use of statistical procedures to explain the central phenomenon underlying the study.

A cross-sectional survey design was used as the research design. Data were gathered from the students at one point in time (Cohen *et al.*, 2007; Leedy and Ormrod, 2010). The cross-sectional survey is advantageous over other

survey designs, in terms of measuring the current state of a phenomenon and helps obtain information from respondents in a short period of time (Creswell, 2012).

The study was targeted to final-year female students in public SHSs in Ghana. Single-sex male SHSs were excluded because the study only included female students. A multi-stage cluster sampling technique was used to sample the female students for the study. First, three out of sixteen regions were randomly sampled using the lottery method. The three regions sampled were Central, Greater Accra, and Ashanti. At this point, it is important to emphasize that only mixed and single-sex female SHSs formed the population of schools in each region. Thus, Greater Accra Region had 52 schools, 59 schools were in the Central Region, and Ashanti Region had 97 schools as of the time of data collection. In each of the regions, five SHSs (excluding single-sex male schools) were randomly and disproportionally selected using the lottery method. Lastly, systematic sampling procedure was used to sample only female respondents from each of the schools. For each school, 150 female students were selected across various programmes of study.

In all, 2,250 respondents were sampled to participate in the study. This sample size was deemed appropriate based on Glenn (1992) recommendation that for a population which is very large and comprise of several sub-groups, the investigator should ensure that there is sufficient representation of each sub-group. The researchers were, therefore, informed by this assertion to select 150 students from each of the 15 schools making a total sample of 2,250. Due to issues of non-response, incomplete response and mortality, 1,938 out of 2,250 were used for the analysis (response rate of 86%).

A questionnaire was used as the main instrument for the research. The greater proportion of the questions or items on the instrument were closed-ended such that options were provided for respondents to select from. Only a few were open-ended. The instrument was pilot-tested in Ahantaman Girls SHS in Sekondi-Takoradi, Western Region. This was done to fine-tune the items on the questionnaire. The instrument was subjected to validation (i.e. validity and reliability) (Quansah, 2017). Response Factor Analysis was used to examine the construct validity of the instrument. Items with low factor loading were modified and some were discarded. Also, Kuder-Richardson 21 was used to estimate the reliability of the items. A reliability estimate of .78 was achieved. Response Factor Analysis and Kuder-Richardson 21 were used in establishing validity and reliability respectively because most of the items were categorical (dichotomous) in nature.

Table-1. Coding of variables for the logistic regression.

Indicators	1	0
Interest in Maths, Science & ICT lessons	Have an interest in lessons	Do not have the interest
Performance	Good	Not so good
Elective Maths status	Elective Maths option	Do not do Elective Maths
Course of study	Science-related	Others
Educational qualification of parents	Having parents with a tertiary qualification	Do not have parents with such degree
Socio-economic status	High	Low
Career indecision	Indecisive	Decisive
Job prospect in STEM	Have job prospect in STEM	Do not have job prospect in STEM
Role model	Those who have the trait	Those not having the trait
Locus of control		
Self-confidence in pursuing STEM		
Stereotype thinking		
Choice of STEM programme**	Will choose STEM	Will not choose STEM
Intentions to further in STEM-related field**	Yes	No

Note: **Criterion variable.

Binary logistic regression with 1,000 bootstrap samples was used to analyse the data. Binary logistic regression, in simple terms, is the non-parametric version of multiple regression analysis. It is used when the criterion variable is dichotomous and predictor variables are also categorical. Binary logistic regression operates on odds or probabilities of how a variable predicts another variable (Field, 2009). The coding for the binary logistic regression is shown in Table 1.

3. RESULTS

This section of the report highlights the results of the study. Using the Binary logistic regression analysis, the predictors were broadly categorised into three dimensions (school-related, home-related, and person-related factors). The criterion variable was the students' decision to choose STEM programme in further education. Table 2 and Table 3 show the results.

Table-2. Omnibus tests of model coefficients.

	Test	Chi-square	df	Sig.
Step 1	Step	666.095	18	<.000
	Block	666.095	18	<.000
	Model	666.095	18	<.000

Note: -2log likelihood=1336.603; Coz & Snell R²= .291, Nagelkerke R²= .452(45.2%).

The results from the Omnibus Tests of Model Coefficients revealed that the model is fit, $X^2(18)=666.095$, $p<.001$ Table 2. The Nagelkerke R² indicated that 45.2% of the variances in students' decision to choose STEM programme in their further education is explained by the school, home and personal factors.

Table-3. Contribution of predictors to the criterion.

Factors	β	Boot S. E.	Wald	Exp (B)	Boot (95%) C.I. for EXP(B)	
					LLCI	ULCI
School-related Factors						
Interest in science lessons	.758	.167	20.529	2.134*	1.537	2.961
Elective Mathematics	.713	.181	15.589	2.040*	1.432	2.907
Course of study (others)	.611	.166	13.490	1.543*	.392	.752
Interest in math lessons	.569	.249	5.220	1.767*	1.084	2.880
Interest in ICT lessons	-.243	.213	1.301	.784	-.517	1.191
Performance	-.563	.401	1.967	.569	-.259	1.251
Home-related Factors						
Educational level of father	.968	.189	34.119	1.698*	.348	1.955
Socio-economic status	1.815	.414	19.208	1.163*	.072	.367
Exposed to STEM at home	-.287	.370	.601	.750	-.363	1.551
Educational level of mother	-.373	.437	.729	.689	-.293	1.621
Person-related Factors						
Role model in STEM	2.560	.295	75.162	6.077*	.043	.138
Career indecision	-3.081	.382	64.921	.046*	.022	.097
Self-confidence	1.669	.260	41.097	5.304*	3.185	8.834
Locus of control	.988	.215	21.153	1.372*	.244	.567
Job prospects in STEM	.545	.171	10.157	1.725*	1.234	2.412
Stereotype thinking	.139	.185	.569	1.149	-.800	1.651
Constant	4.533	.519	76.416	93.01		

Note: *significant at .05 level; LLCI- Lower limit confidence interval; ULCI- Upper limit confidence interval.

As shown in Table 3, it was revealed that school-related factors such as course of study ($\beta= .611$, $OR=1.543$, $CI [.392, .752]$), elective mathematics status ($\beta= .713$, $OR=2.040$, $CI [1.432, 2.907]$), interest in mathematics ($\beta= .569$, $OR=1.767$, $CI [1.084, 2.880]$), and interest in Science ($\beta= .758$, $OR=2.134$, $CI [1.537, 2.961]$), significantly predicted SHS female students' choice of STEM-related programme for further studies in the tertiary level. Interest

in ICT and Teachers were non-significant predictors of SHS female students' choice of STEM-related programme for further studies at the tertiary level.

For home-related factors, educational of the father ($\beta = .968$, $OR = 1.698$, $CI [.348, 1.955]$), and socioeconomic status ($\beta = 1.815$, $OR = 1.163$, $CI [.072, .367]$) were found as significant predictors of SHS students' choice of STEM-related programme for further studies in the tertiary level [Table 3](#). Exposed to STEM at home and educational level of mothers were non-significant home-related factors influencing SHS students' choice of STEM-related programme for further studies at the tertiary level.

The study also found that the majority of the person-related factors were significant predictors of SHS students' choice of STEM-related programme for further studies at the tertiary level. Among the factors are self-confidence ($\beta = 1.669$, $OR = 5.304$, $CI [3.185, 8.834]$), career indecision ($\beta = -3.081$, $OR = .046$, $CI [.022, .097]$), role model in STEM ($\beta = 2.560$, $OR = 1.077$, $CI [.043, .138]$), locus of control ($\beta = .988$, $OR = 1.372$, $CI [1.234, 2.412]$), and job prospect in STEM ($\beta = .545$, $OR = 1.725$, $CI [1.234, 2.412]$). Stereotype thinking, however, was not a significant predictor of SHS students' choice of STEM-related programme for further studies at the tertiary level.

4. DISCUSSIONS

The findings from our study revealed that school-related factors such as the course of study, elective mathematics status, interest in mathematics and Science lessons, significantly predicted SHS students' choice of STEM-related programme for further studies at the tertiary level. Explicitly, students reading a science-related course had higher odds of choosing STEM programmes in further education. It can be speculated that these students might believe that once they find themselves in a science-related field, they should continue to pursue further studies in that line. Similarly, those who had interest in mathematics and science lessons also had a higher probability of choosing STEM-related programmes in further education. Again, students who registered for elective mathematics had higher chances of selecting STEM programmes. It is important to highlight that these subjects (i.e., mathematics, science, and elective mathematics) are fundamental to students who intend to pursue further studies in STEM. Once students are exposed to these subjects and they might probably develop interest in them, and as such it is easy for the students to pursue related programmes. Several studies have confirmed this indicating that initial experience in mathematics influences people in going into STEM education (e.g., [Bowman, 1998](#); [Adelman, 1999](#); [Marshall et al., 2011](#)). Our findings corroborate the study by [Awan et al. \(2017\)](#) which was conducted among 1st-year university students in STEM in Pakistan. [Awan et al. \(2017\)](#) concurred that interest in STEM-related subjects influences students to pursue further studies in STEM. Similar findings were revealed by [Boateng and Gaulee \(2019\)](#) and [Wang \(2013\)](#).

The educational level of the father other than the mother influences the choice of students in pursuing STEM programmes. In the Ghanaian society, the father is considered as the "head" of the family. As such the majority of the decisions made concerning the home and the children are spearheaded by fathers. This result portrays the dominance of fathers in the career decisions of their children. This probably might be as a result of the father taking care of the children in school. The mothers are always oriented to be washing, cooking and taking care of the home whereas fathers are been made to believe that they have to toil and provide for the family. Previous studies have averred that fathers play a critical role in decisions concerning their children ([Acheampong, 2014](#); [Awan et al., 2017](#); [Ankoma-Sey et al., 2019](#); [Boateng and Gaulee, 2019](#)).

As part of the home factors, socio-economic status was also found as a significant predictor of the choice of STEM programmes. Students from a high socio-economic background had higher odds of choosing STEM programmes in their further education. There is a general impression that educating people in STEM-related fields

is expensive such that parents who struggle to take care of their children in school do not usually encourage their children to pursue STEM programmes. Supporting this finding, numerous academics have stressed that a significant number of students who do not pursue STEM programmes have are from the low socio-economic status (Anderson and Kim, 2006; Herrera and Hurtado, 2011; Schultz *et al.*, 2011).

Person-related factors also play a crucial role in students' choice of the STEM programme. Among the factors are self-confidence, career indecision, a role model in STEM, locus of control, and job prospect in STEM. Students who have high confidence, low career indecision, having job prospect and role model in STEM, and strong locus of control had higher chances of pursuing STEM programmes. This finding supports the social cognitive career theory which postulates that the will-power to produce a specific choice can be described as a function of goals and interests. The theory further stated that interest in a choice action is related to learning experiences and self-reference confidence (Marshall *et al.*, 2011). From Pajares and Kranzler (1995) perspective, intentions to choose STEM-related programmes is related to previous academic achievement and self-efficacy beliefs. These studies are consistent with the findings of this study.

5. CONCLUSIONS AND RECOMMENDATIONS

Our study revealed an influential interplay among factors from home, school and personal traits in the decisions of female students in the choice of STEM-related programmes in tertiary education. It was obvious that the persistence of some key drivers decreased the probability of students choosing STEM-related programmes. These drivers include low interest in mathematics and science lessons, failure to take elective mathematics as a major, having father without tertiary education, low socioeconomic status, not having a role model in STEM, low confidence in pursuing STEM, weak locus of control and no job prospect in STEM.

The results have implication for the realisation of SDG 5 (Agenda 2030) and Agenda 2063 of the African Union. This study becomes a starting point for interventional strategies to be rolled out by these agencies in order to reduce the gender gap in pursuing STEM programmes. This is to say that the United Nations and the AU should do well to tackle the aforementioned factors which influence female students' choice of programmes of study. By giving attention to these key drivers from home, school and those personal in nature, students' decisions and choices would be influenced positively towards choosing STEM-related programmes.

Based on the findings of the study, we gave the following suggestions:

1. Teachers who teach science and mathematics should develop teaching strategies to boost the interest of students in these subjects.
2. School authorities and counsellors should organise programmes for female students to build their confidence and locus of control. These programmes should educate students on the need to get a role model in STEM and further going into STEM fields.
3. Parents also need to provide the needs of their girl-child when in school. These include expenses related to food, books, and other personal pieces of stuff the child might need.
4. School counsellors also have a role to play in guiding female students to make appropriate choices. Counsellors should provide students with the necessary information to make informed decisions regarding the choice of STEM programmes.

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